

INVESTIGATION OF TOOL LIFE IN AL / SIC COMPOSITE MATERIAL WITH ULTRASONIC WAVES MACHINING

BEHZAD ABBASZADEH & AMIR GHAFOURI

Department of Engineering, Payame Noor University (PNU), Tehran, Iran

ABSTRACT

The machining process is one of the most widely used methods in manufacturing metal parts. The most important issues of machining are the life of the tool. The life of the tool, in turn, is influenced by the regulatory process parameters. The life of the tool represents the useful life of the tool, which is expressed in terms of the time from the moment of the beginning of the cut to the ending point which is determined from the day of the standard of disability. The parameters of this process have different effects on the abrasion of the tools. Therefore, one of the problems that are mixed with this process is the choice of optimal parameters to achieve the most favorable abrasion tool. The main objective of this study was to investigate the effective parameters of machining (cutting speed, feed speed and cutting depth) on the life of a titanium nitride-coated steel thinner tool on an ultrasonic perforation drilled AL / SIC composite material... In order to collect the experimental data, the Taguchi design was used in the design of the experiments. Then, with the help of ANOVA, the parameters levels are determined in order to maximize the life of the tool. The results showed that cutting velocity, cutting rate and cutting depth increased tool wear and reduced tool life in the AL / SIC material.

KEYWORDS: Ultrasonic Waves Machining, Optimization, Tool Life & Test Design

Received: Apr 06, 2018; **Accepted:** Apr 27, 2018; **Published:** May 17, 2018; **Paper Id.:** IJMPERDJUN201854

INTRODUCTION

In recent years, due to the discovery of advanced manufacturing techniques, the industry has developed a great deal, so cutting tools has become especially important. So much research has been done to increase the life of tools, on the kind and design of cutting tools to meet industry needs.

Today, manufacturers are seeking to improve the quality of products and reduce their cost. Machining and cut of metals are one of the most important processes in producing metal parts, which is widely used in various industries. The quality of the parts and machining costs are directly affected by the geometry of the tool and the cutting parameters. In this regard, the studies in machining mainly focused on the kind, tool geometry, and machine parameter settings. Cutting tools are one of the important factors in increasing the efficiency of machining operations. The cutting tool wear is one of the major constraints in the manufacture of parts with good quality and reasonable price. The failure of the tool often occurs in three modes of sharp edge wear, a plastic deformation of the sharp edge, and a change in machining conditions such as surface quality or vibration of the device [6].

Modern machining materials, such as superalloys and composites, are always subject to many problems, including wear tools, high machining forces, and poor surface quality. Generally, non-traditional machining is introduced to solve this problem, and each of these methods has many problems, including high cost, high

machining time and non-availability. The use of ultrasonic waves as an auxiliary process in the modern materials industry has occupied a special place in the last two decades. One can mention drilling with ultrasonic waves.

In the process of machining with ultrasonic waves, the normal tool used in the machining process, in addition to rotary motion, has a vibrational motion. This vibration is added to the normal machine and helps to crashing. Vibrations are produced by a generator that task is to convert urban electric waves to high mechanical frequency waves. The waves produced by the piezoelectric cells concentrated are boosted and eventually applied to the instrument or workpiece.

So far, many activities have been done in the field of ultrasonic welding. In some materials, different parameters of machining are investigated empirically and optimization of its parameters has been done with different methods. But there are still materials that have not been thoroughly investigated due to the robust machinist in terms of the effect of different parameters on them, one of which is an aluminum compound composite material reinforced with silicon carbide particles. Due to the presence of hard silicon carbide abrasive particles, this material causes tools wear and high force on the drilling[9]. Chandra and et al. studied the effect of ultrasonic waves on DF steel. Their results showed that the wear of a much higher tool in normal mode than the ultrasonic wave mode was produced [2]. Using the Taguchi method and analysis of variance, Nalbant and et al. determined the optimum effect of the tool tip radius, feed speed, and cutting depth to achieve the optimum surface fineness in AISI1030 steel turning [7]. Aslan and et al. examined the effect of shear parameters on tool wear and surface smoothness in hardened steel turning operation and presented the relationship between them in a mathematical model [1]. Manna and Salodkar have determined the optimum cutting conditions to achieve the desired optimum surface smoothness and minimum machining cost in the EO300 alloy turning operation [5]. For the machining of aluminum, Fang and Wu, the effect of tool edge geometry on cutting forces, machining power and cutting thickness have been investigated [3]. Altanand et al. studied the effect of tool edge geometry, bending angle, tool radius, and cutting speed empirically and simulated in 100CR6 steel[4]. According to the research, it is clearly seen that so far in the field of ultrasonic machining, most studies have been investigated and the positive impact of ultrasonic waves on material machining has been studied. In the field of tool life, less research has been done. In this paper, the lifetime of tools in the composite AL / Sic machining was performed using ultrasonic waves.

DESIGN OF EXPERIMENT

In order to investigate the effect of machining variables (cutting velocity, feed speed, and cutting depth), the design of the test was carried out using the Taguchi method [8] and with the aid of the Minitab software. For this purpose, three variables were changed at three levels and the number of experiments was selected based on the number of input parameters with Taguchi design. The Taguchi design proposes three factors, three-level input for the orthogonal L_{18} array. In this paper, the machining parameters were chosen to be within reasonable limits. The range of values for machine variables is presented in Table 1.

Table 1: Range of Quantities of Machining Variables

| | Cutting Depth (mm) | Feed Speed (mm/rev) | Cutting Speed (m/min) |
|-----|-----------------------|------------------------|--------------------------|
| Min | 0.2 | 0.09 | 17 |
| Max | 0.6 | 0.17 | 33 |

At all stages of the process, the rotational speed of relation (1) is used, in this case, D is the diameter of the work piece, V is the cutting rate and n is the number of rotation in rpm.

$$n = \frac{v \times 1000}{\pi \times d} n = \frac{v \times 1000}{\pi \times d} \quad (1)$$

The basis for determining the life of the tool in this research is the use of the criterion life measure of the tool (relation 2), that v is the volume of removal, D is the diameter of the workpiece, d is the cut depth and L is the length of the workpiece, which during machining, quality Its surface is 1.5 times higher.

$$\frac{1}{v} = \frac{1}{\pi \times D \times d \times l \times 10^3} \quad (2)$$

To collect the data, the experimental design approach has been used by Taguchi method. Taguchi provides a functional approach in the field of quality control of manufacturing industries. The main objectives of the Taguchi method are to determine the effect of each of the parameters on the output of the process and determine the optimal levels of these parameters. The Taguchi method achieves these goals by analyzing empirical data that has been collected in predetermined terms.

EMPIRICAL TESTING

The selected piece is a cylinder made of silicon carbide-reinforced aluminum composite material with a diameter of 10 mm and a length of 100 mm, the titanium nitride-titanium-plated steel cutting tool having an open angle of 6° and the swarfangle is 14 degrees and has been machined in the process of turning with ultrasonic waves. To create electric waves, Master sonic product from the ultrasonic generator is used. The transducer is used in a piezoelectric ultrasonic set and a Master sonic product. For making empirical testing, the universal machine that made by Tabriz was used. To apply ultrasonic vibrations to a rotating drill tool, a special tool attached to an ultrasonic transducer can be used on a spindle of a lathe. Figure 1 shows how to test on the device.



Figure 1: Test Setup

Also, for performing empirical experiments, three variables, including cutting speed (17.25 and 33 m / min), progressive rate (0.09, 0.13 and 0.17 mm / h) and cutting depth (0.2, 0.4 and 0.6 millimeters). An aluminum composite material with a particle size of 63 microns, reinforced with silicon carbide particles of 18-20 microns, was produced by powder extrusion for empirical work. With using of modal analysis by Abaqus software for concentrating design, the optimal vibrational frequency of 21.7 kHz was achieved. Also, the constant vibration range was 5 microns.

Table 2, shows the values of the levels of input parameters and test results based on the above criteria.

Table 2: Matrix of Experiments and Output Results

| Surface | Feed Speed (mm/rev) | Cutting Speed (mm/min) | Cutting Depth (mm) | Criterion of Life Time Tool |
|---------|---------------------|------------------------|--------------------|-----------------------------|
| 1 | 0.09 | 17 | 0.2 | 41.176 |
| 2 | 0.13 | 25 | 0.2 | 51.257 |
| 3 | 0.17 | 33 | 0.2 | 36.868 |
| 4 | 0.13 | 17 | 0.4 | 37.703 |
| 5 | 0.17 | 25 | 0.4 | 40.823 |
| 6 | 0.09 | 33 | 0.4 | 48.179 |
| 7 | 0.17 | 17 | 0.6 | 35.295 |
| 8 | 0.13 | 25 | 0.6 | 37.7 |
| 9 | 0.09 | 33 | 0.6 | 70.872 |

Analysis of Data

The purpose of analyzing engineering tests is to study the factors affecting a phenomenon and the effect of the relationship between these factors on the change of the phenomenon. Analysis of variance is one of the statistical analysis methods that achieve the best performance and performance conditions by analyzing the results. For analysis of variance, the Minitab software has been used.

To measure the participation percentage of each factor, the analysis of variance was used in the lifetime of the tool. The analysis of variance showed that the cutting speed is more than the progress rate and the effect of the progress rate over the cutting depth on the life of the tool.

Analysis of Results

After the experiment, the effect of each of the parameters on the lifetime of the following relationships was observed.

Effect of Cutting Speed on Tool Lifetime

According to figure. 2, the life of the tool decreases with increasing cutting speed. The main reason for decreasing the life of the pen due to the cutting speed is the increase in temperature at the turning chisel level. By increasing the heat generated, the wear on the tools at the filing level (erosion pit) and at the free surface (the threshold of erosion) increases and reduces the life of the chisel. Therefore, at high cutting speeds, the cooling power of the fluid plays a more important role. Cutting speed is a direct characteristic of the cost involved in the production of the piece, and therefore the machining rate based on cutting speed and the life of the tool is a good basis for comparing different materials. Cutting speed as a variable has the greatest impact on the life of the tool. Due to the relation of the cutting speed and the tool life, a suitable value for cutting speed should be selected.

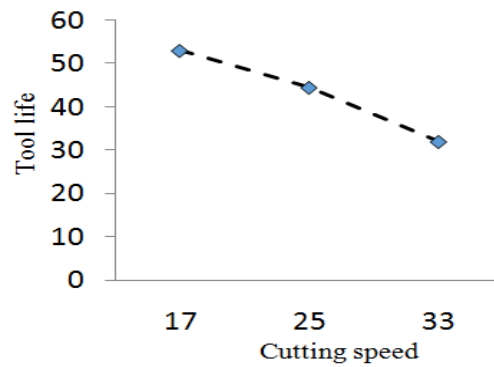


Figure 2: Effect of Cutting Speed on Tool Life

Effect of Feed Speed on Tool Life

Tool life is affected by a certain cutting speed of progress rate. Progressive speed affects the cutting force and cutting rates. As the progressive rate rises, the temperature increases on the surface of the chisel and when the temperature increases chisel life decreases. The effect of feed speed on the tool life is less than that of the cutting speed.

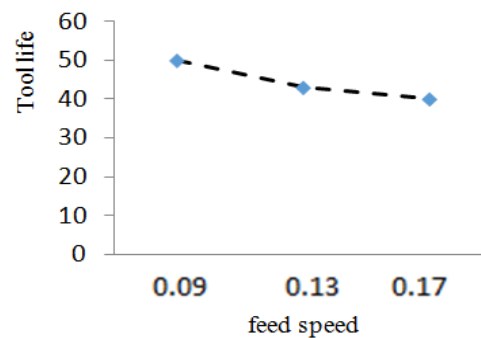


Figure 3: Effect of Feed Speed on Tool Life

Effect of Cutting Depth on Tool Life

In figure 4, the chisel life decreased by increasing the cutting depth. The reason is the creation of temperature on the filing and freeing the surface of tools. The large cutting depth increases the cutting forces of the tool and reduces tool life.

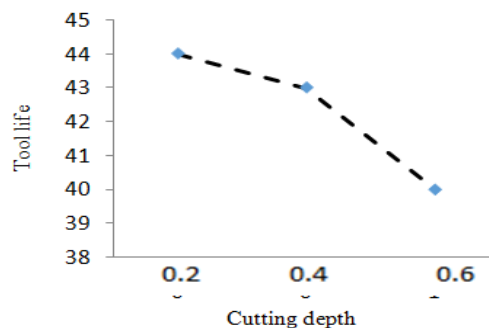


Figure 4: Effect of Cutting Depth on Tool Life

RESULTS AND CONCLUSIONS

In this paper, based on the experimental data obtained from the machining process of AL / Sic composite material, the effect of machining parameters on the life of high-speed steel tool that coated by the titanium nitride was investigated. The results showed that the effect of inlet parameters of the cutting speed is higher than the feed speed and the effect of the feed speed on tool life.

In machining of Al / Sic composite material, cutting speed has the greatest effect on tool wear. The tool wear is 33 times, twice as fast as 17m/min. The second most effective parameter on tool wear is the feed speed, when it increases then the tool wear rising. The cutting depth is the next effective factor on the wear of the tool, when it increases then the tool wear rising.

By increasing the cutting speed, the life of the tool decreases. The main reason is the increase in temperature at the chisel level. By increasing the heat generated, the wear of the tools at the cutting level (erosion pit) and at the free surface (the threshold of erosion) increases and reduces the life of the chisel.

Cutting speed is a direct characteristic of the cost involved in the production of the piece, and therefore the machining rate based on cutting speed and tool life is a good basis for comparing different materials.

Tool life is affected by a certain cutting speed of progressive rate. Progressive rate affects the cutting force and rate.

The large cutting depth increases the cutting forces of the tool and reduces tool life.

According to the results, the optimal points of each of the parameters should be selected. The choice of cutting variables in machining is usually difficult and requires experimental tests and optimization operations. Optimization algorithms such as genetic algorithms can be used to optimize important parameters in machining such as tool life and surface quality.

ACKNOWLEDGMENTS

The authors are grateful for the careful observations and suggestions of the reviewers that improved the final version of this paper.

REFERENCES

1. Aslan, E. Camuscu, N. and Birgoren, B. *Design Optimization of Cutting parameters When Turning Hardened AISI 4110 Steel(63 HRC)With AL203+TiCNMixed Ceramic Tool*", *Materials and Design*, Vol.28, pp.1618-1622, 2007.
2. Chandra, N. Rahman, M. and. Andrew, S. K. *A study on ultrasonic vibration cutting of low alloy steel*, *Journal of Materials Processing Technology*, vol.90, pp. 192–193, 2007.
3. Fang, N. and Wu, Q., *"The Effects of Chamfered and Honed Tool Edge Geometry in Machining of Three Aluminum Alloys"*, *International Journal of Machine Tools & Manufacture*, Vol. 45, pp. 1178–1187, (2005).
4. Gandole, Apurva Y., Omkar S. Ghatpande, and Tushar R. Jadhav. *"Modeling and Simulation of Ultrasonic System."*
5. Kountanya, R., Al-Zkeri, I. and Altan, T., *"Effect of Tool Edge Geometry and Cutting Conditions on Experimental and Simulated Chip Morphology in Orthogonal Hard Turning of 100Cr6 Steel"*, *Journal of Materials Processing Technology*, Vol. 209, pp. 5068–5076, (2009).

6. Manna, A. and Salodkar, S. optimization of Machining conditions for Effective Turning of EO300 Alloy Steel, *journal of materials processing technology*, Vol.203, pp.143-157, 2008.
7. Mukherjee, I. and Ray, K. R., "A Review of Optimization Techniques in Metal Cutting Processes", *Computers & Industrial Engineering*, Vol. 50, pp. 15-34, (2006).
8. Nalbant, M. Gokkaya, H. and sur, G., Application of Taguchi Method in the optimization of Cutting parameters for Surface Roughness in Turning, *Materials and Design*, Vol. 28, pp.1379-1385, 2007.
9. Ross, P. j. *Taguchi technique for quality engineering*, New York McGraw Hill, 1988.
10. Surappa, M. K., *Aluminum matrix composites: Processing and Properties*, vol.28, pp. 319-334, 2003.

